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A DYNAMIC HUMAN ENGINEERING EVALUATION OF THE ARMORED PERSONNEL CARRIERS T113 & T117

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ABSTRACT

Report of a static evaluation of the T113 and T117 Armored Personnel Carriers. This evaluation was conducted to uncover human engineering design deficiencies and to note areas in which the vehicles proved adequate from a human engineering standpoint. Findings indicated necessity for more intensive investigation. Primary investigation was done in: (1) sound measurement and analysis within vehicles with full complement of personnel; (2) effects of noise on audition, communication, and performance; (3) effects of vehicle configuration and design on crew performance, safety, and comfort; (4) crew's opinion on 1, 2, and 3 above.

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DYNAMIC HUMAN ENGINEERING EVALUATION

OF THE ARMORED PERSONNEL CARRIERS T113 AND T117

INTRODUCTION

In 1957 a Field Liaison team of the U. S. Army Ordnance Human Engineering Laboratory (HEL), Aberdeen Proving Ground, Maryland, conducted a static evaluation of the T113 and T117 Armored Personnel Carriers at the Food Machinery Corporation, San Jose, California. This evaluation was conducted to uncover human engineering design deficiencies and to note those areas in which the vehicles proved adequate from a human engineering standpoint.

The findings of the study indicated the necessity for more intensive investigation. For example, excessive sound levels within the vehicles were found which might affect audition, communication, and general crew performance. (For additional findings see HEL TM 10-57.) In order to adequately determine the extent and nature of the problems encountered, the Field Liaison team conducted a dynamic evaluation of the vehicles at Fort Knox, Kentucky. The testing was run concurrently with U. S. Army Armor Board user-tests of the vehicles. Data on two M59 vehicles were also obtained for comparative purposes. (No formal comparison was made between test vehicles since the major difference was that the T113 is aluminum and the T117 is steel.) Primary efforts were directed in the following areas:

a. Sound measurement and analysis within all vehicles with a full complement of personnel.

b. Effects of noise on audition, communication, and performance.

c. Effects of vehicle configuration and design on crew performance, safety, and comfort.

d. Crew opinion concerning a, b, and c above.

FIG 1. Comparison shot of the troops dismounting the M59 and the T117.

PROCEDURE

The human engineering tests were integrated into the Armor Board Test Schedule, in which the vehicles were evaluated with a full crew for one week under various tactical situations. The Armor Board Test Schedule is presented in the Appendix.

The following tests were performed, when their application was appropriate to the Armor Board's Schedule:

a. Sound-level measurements were taken in all vehicles with a full complement of personnel during travel over primary and secondary roads for a period of two hours. Intensity measures were taken in each octave band in addition to overall intensity levels. These measurements were taken at ear level in five different locations within the Personnel Compartment of the three vehicles. The locations were: front, left and right, rear, left and right, and center.

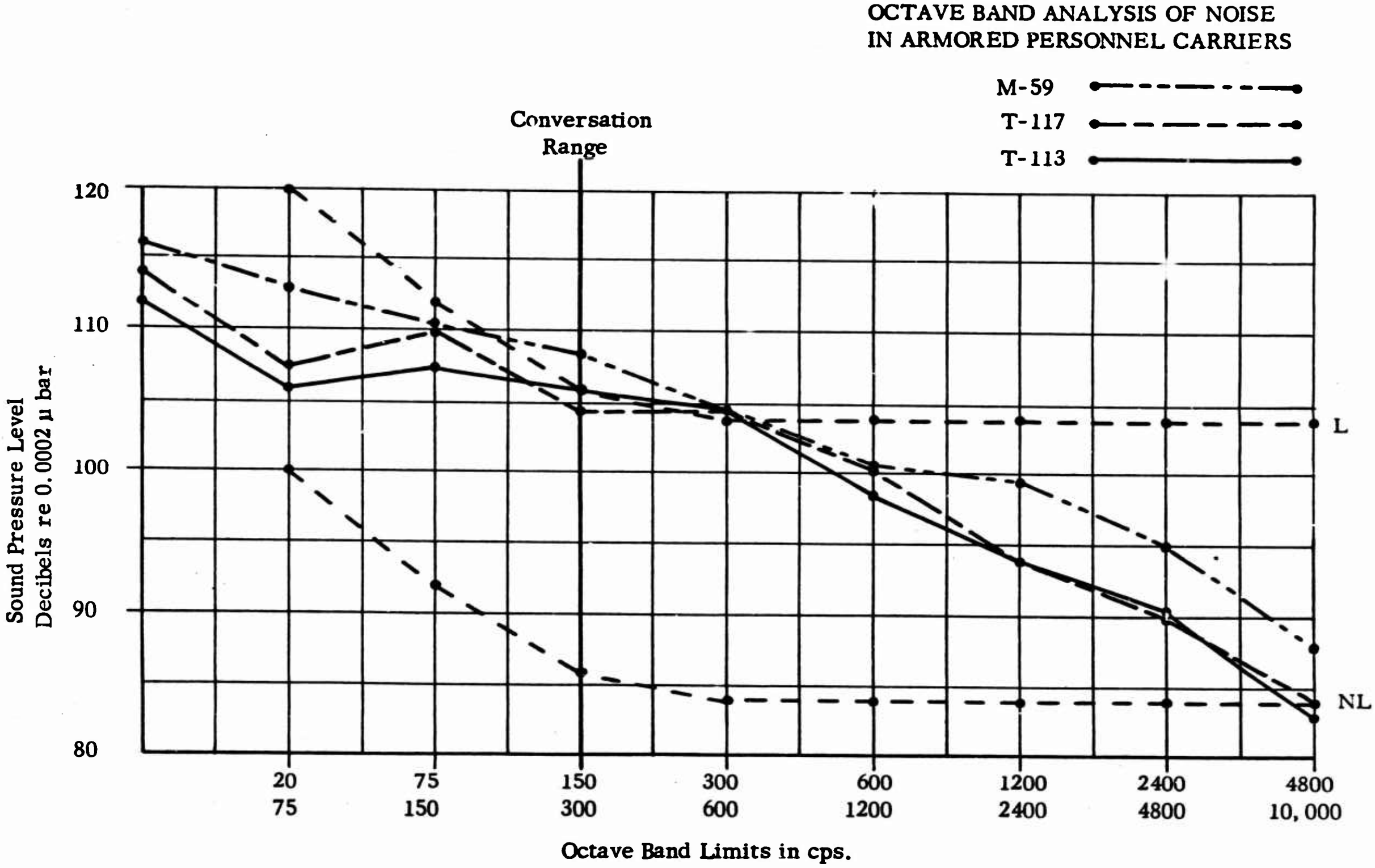
b. The extent and nature of any hearing loss which might have resulted from the sound levels within the vehicles were determined by audiometric examinations. Audiograms were obtained for six men who had no previous experience with any of the vehicles. These six individuals were divided into three two-man groups and were required to ride in either the T113, T117, or M59 for a period of two hours over primary and secondary roads. Audiometric examinations were repeated shortly afterwards (5 to 55 minutes) and 30 hours after having ridden in the vehicles. Three additional groups of two men each, who had previously ridden in the M59 vehicle and not the T113 or T117 vehicles, were also tested before and after operations, but not 30 hours thereafter. Hearing loss of the first three groups who had never ridden in any personnel carrier prior to the test was compared with the hearing loss of those who had ridden only in the M59.

c. A test was performed to determine any difficulties that might be encountered in mounting or dismounting because of vehicle configuration (Fig. 1). A T117 and an M59 were parked side by side with the ramps lowered. An Armored Infantry Squad was assigned to each vehicle; they were required to dismount and stand in a diamond formation 15 yards in front of the vehicle. Then they formed a line 10 yards in front of the vehicles and mounted the vehicles. Each squad was given three practice runs and three test runs; then each squad was assigned to another vehicle and the procedure was repeated. Motion pictures were taken, and times for each squad to mount and dismount were recorded.

d. In order to determine the effects of riding in the vehicle on fighting performance, each squad was required to travel over a cross-country course for one hour, dismount, and assault a hill. Motion pictures were taken, and times to accomplish the assault were recorded. Two Armor Officers observed the operation to judge squad proficiency.

TABLE 1. SOUND LEVEL READINGS FOR EACH VEHICLE FOR ALL FREQUENCIES

OCTAVE BAND ANALYSIS OF NOISE
IN ARMORED PERSONNEL CARRIERS



e. Because of amphibious capability requirements, all the vehicles made a hasty river crossing with a full complement of personnel. No formal test of this tactical procedure was performed by the Field Liaison team. However, observations were made and photographs were taken of the entire operation in order to detect any human engineering problems which might have arisen.

f. An Armor Board driver familiar with both vehicles performed preventive maintenance on the M59 and the test vehicles so that ease of maintenance could be compared. The driver was questioned and his performance was observed and photographed.

g. All personnel were interviewed before and after the week's operations. They were questioned on design deficiencies and adequacies that were not tested nor apparent to the observers. Crew opinion was elicited on all aspects of the vehicles' operation, performance, safety, and comfort.

RESULTS AND CONCLUSIONS

The sound-level readings obtained from each of the three vehicles for all frequencies investigated are presented in Table 1. Each point on the graph represents the mean decibel for all positions within a given vehicle. A person exposed to the noise level represented by the upper curve (L) for over a period of years will incur hearing loss. No hearing loss will be sustained at levels below the lowest curve (NL). Therefore, personnel who are expected to frequently ride in the T113, T117, and M59 vehicles for a period of more than one year assume the risk of sustaining a hearing loss in those frequencies which equal or exceed curve L shown in Table 1. It is noted that the probability of permanent hearing loss is greatest in the frequencies which lie in the conversation range, i.e., 250 to 500 cycles.

Audiometric examinations indicated that all men who rode in the vehicles sustained a temporary hearing loss. The greatest loss occurred in the conversation frequencies which are noted below. The mean hearing loss for those men tested up to 30 minutes after the ride was 12.2 dB at 250 cycles and 9.4 dB at 500 cycles. The mean hearing loss for those men tested 30 to 60 minutes after the ride was 8.3 dB at 250 cycles and 8.3 dB at 500 cycles. Although the sample was not large enough for a statistical comparison, there was no indication that one type of vehicle caused more or less hearing loss that the other type. Of those examined, hearing had returned to normal 30 hours after exposure.

Table 2 presents the times recorded for each squad to mount and dismount from each of the parked vehicles. Although differences in performance were small, it is noted that lower mean times for both mounting and dismounting were obtained with the M59.

TABLE 2

Times Recorded to Mount and Dismount

From Each of the Parked Vehicles

SQUAD I

	1st T117			2nd M59	
Trial	Mount	Dismount	Trial	Mount	Dismount
1	10.1	9.5	1	8.2	8
2	10	9.4	2	6.8	7.9
3	9.2	8.6	3	7.5	7.8
Mean	9.8	9.2	Mean	7.5	7.9

SQUAD II

	1st M59			2nd T117	
Trial	Mount	Dismount	Trial	Mount	Dismount
1	8.8	8.5	1	9.8	9.2
2	8.3	8.3	2	8.9	8.8
3	8.0	8.0	3	8.8	8.7
Mean	8.4	8.3	Mean	9.2	8.9

When the men were required to travel cross-country, dismount and assault a hill, the Armor Officers and HEL observers concluded that performance did not differ as a function of riding in a particular vehicle.

Major difficulties observed or obtained either from photographs or by questioning the personnel concerning the test vehicles were:

a. A driver 5' 4" was too short to operate the accelerator without becoming very fatigued when seated in the unbuttoned position. A man 6' 1" was too tall to sit in the driver's seat with a helmet in the buttoned position (Figs. 2 & 3). For further information see TM 10-57.

b. There was insufficient padding located around the driver's and commander's periscopes.

c. It was difficult for the drivers to mount the vehicles (Fig. 4).

d. The driver must leave the vehicle, climb to the top, and open a hatch to check the transmission oil.

e. The driver and commander had difficulty entering and leaving their seats (Fig. 5).

f. "Blind" areas were found in the driver's and commander's fields of view through the periscopes.

g. Reading the oil dipstick was difficult.

h. The commander had difficulty bracing himself within the vehicle when seated in the "down" position.

i. The commander could not reach the radio controls adequately (Fig. 6).

j. The T-shaped screw lock which permits the commander to turn his cupola could not be easily reached when wearing full field gear (Fig. 7).

k. There was insufficient room between the top of the commander's head and his hatch when he was wearing a helmet.

l. Shovel handles and other personal combat equipment were caught between the bench and walls of the test vehicles (Fig. 8).

m. The cargo hatch cannot be opened while the commander's hatch is open (Figs. 9 & 10).

n. There was no provision for storing and securing equipment within the vehicle and, as a result, it was scattered throughout the vehicle while traveling cross-country (Fig. 11).

o. The squad members were frequently thrown about unexpectedly when the vehicle encountered rough terrain or when the driver "braked" suddenly.

p. Men slipped on the ramp and dropped equipment when dismounting. This condition was aggravated when the ramp was wet and muddy (Fig. 12).

q. There was insufficient storage space for OVM and squad equipment (Fig. 13).

r. The radio channel on which the vehicle commander was receiving his orders was inadvertently changed by a crew member who brushed against the controls (Fig. 14).

s. The corner of the radio jutted into the shoulders of the men sitting next to it (Fig. 15).

t. The squad leader had difficulty hearing the commander's orders and was unable to communicate these orders to the squad while the vehicle was moving.

u. The noise level within the vehicle was irritating.

v. The area on each side of the commander's platform is too narrow to accommodate a man confortably.

w. No light is provided for the squad members.

x. When the vehicle stopped on uneven terrain the ramp did not rest on the ground, and acted as a springboard when the men dismounted.

y. In order to alleviate the fears of a water crossing, the floating capabilities of the vehicles were demonstrated to the using troops.

z. Several cases of nausea within the personnel compartment were encountered due to the pitching and rolling of the vehicle coupled with the exhaust fumes from the engines.

aa. Drain plugs were lost and had to be replaced. Installation was difficult and lengthy.

bb. Bilge pumps were often clogged and after cleaning them it was necessary to flood the vehicles to test pump operation.

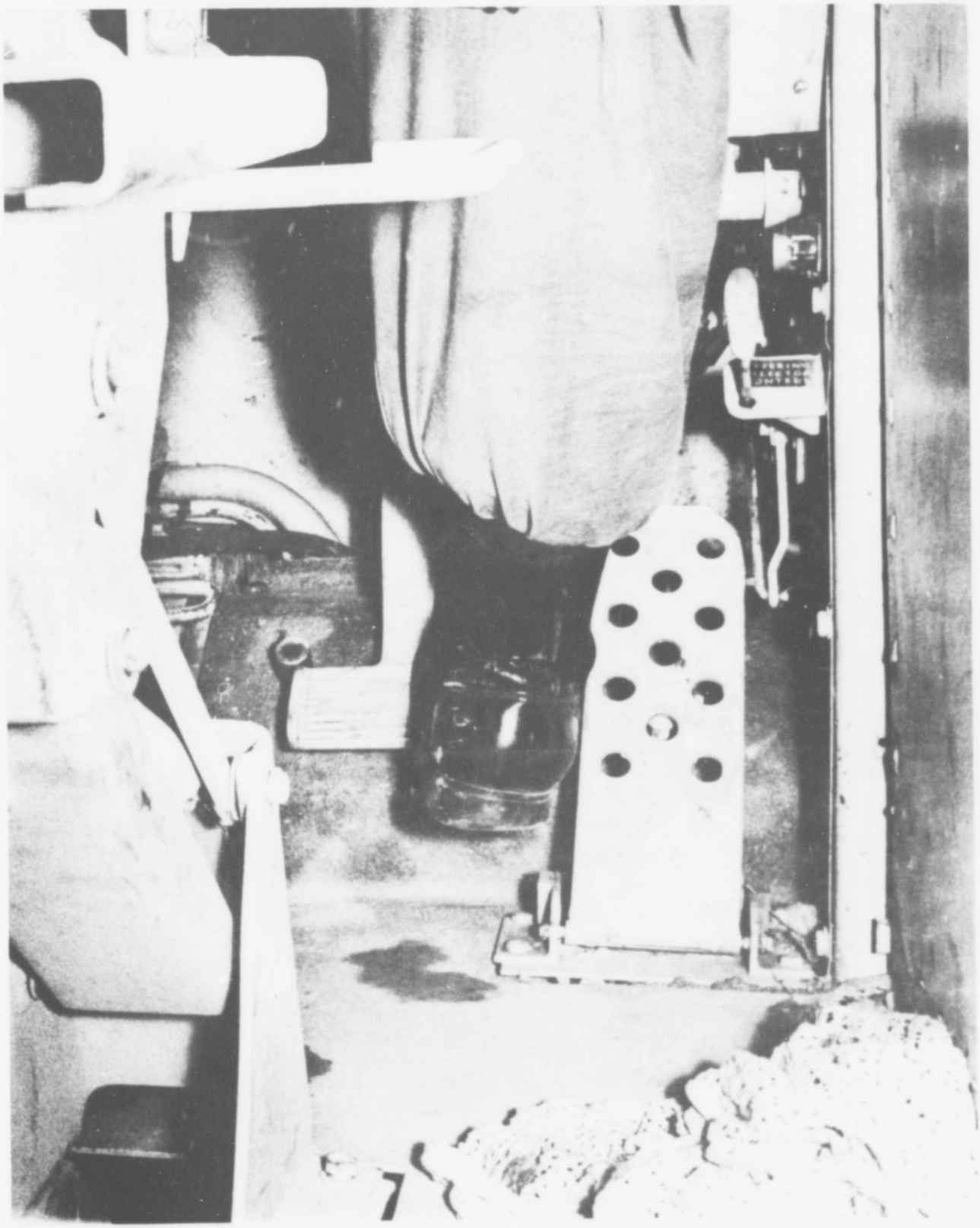


FIG 2. Driver in the "up-position" stretching for the foot pedals.

FIG 3. A tall driver in the "down-position" with full field equipment cannot sit properly without being in a cramped position.

FIG 4. Driver taking his first step to climb aboard the vehicle. Note the stretch.

FIG 5. Driver struggling to get seated.

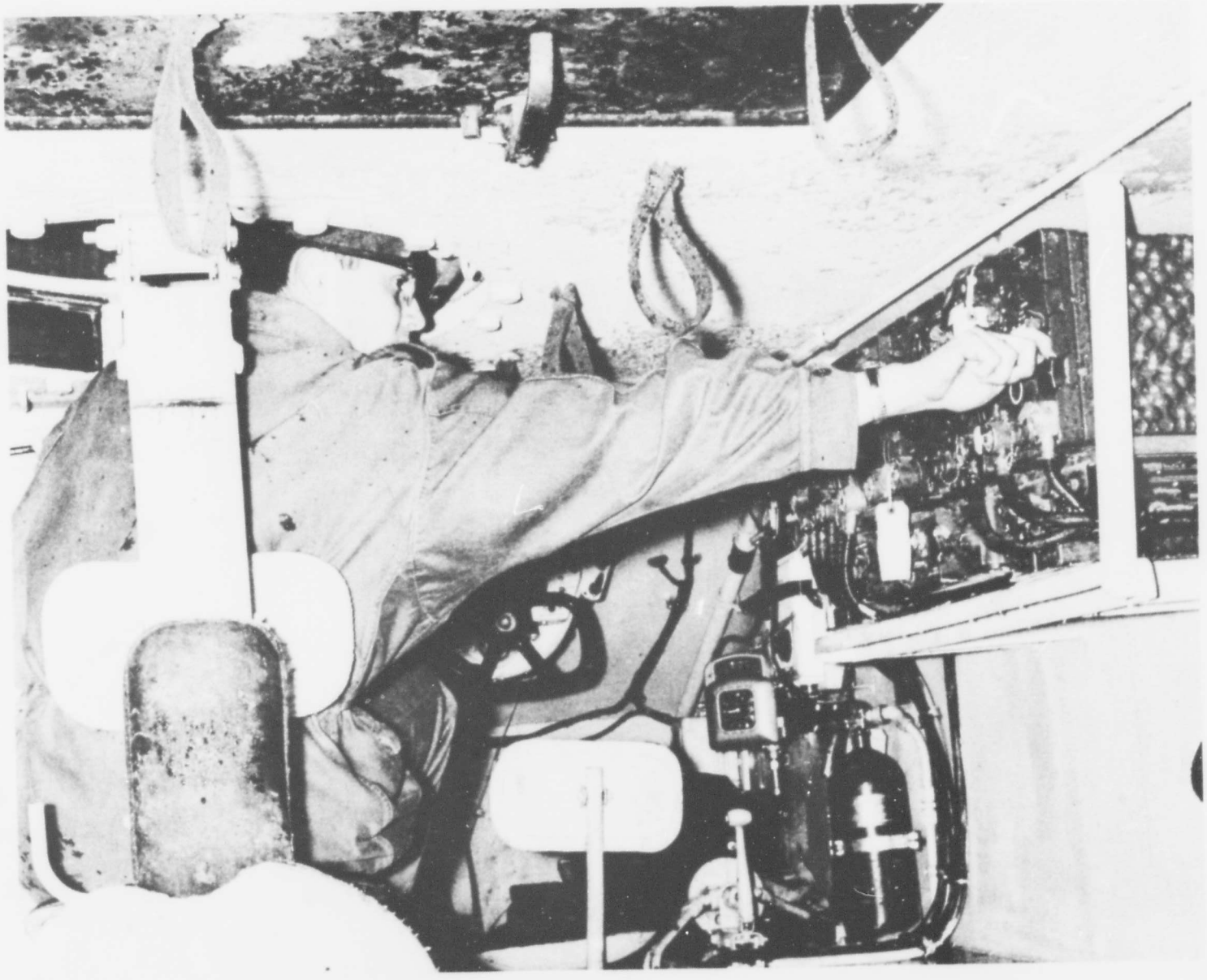


FIG 6. In order to reach the radio, the Commander must lower his head out of the cupola thereby losing command of the terrain.

FIG 7. While riding over rough terrain, the Commander tried to tighten the cupola. After some delay he located the cupola lock. Due to his unfamiliarity with the mechanics of the cupola lock, he unscrewed the lock. This picture shows a squad member finally coming to his aid.

FIG 8. The space between the bench and the wall in the personnel compartment is apt to catch items such as the shovel.

FIG 9. When the Commander's hatch is up the hatch blocks the cargo hatch from opening. This presents a dangerous situation in case of an emergency.

FIG 10. Another scene of the condition shown in FIG 9.

FIG 11. Result of a rough terrain ride with full equipment in the vehicle.

FIG 12. Soldier skidding on a wet ramp without any non-skid coating or horizontal bars.

FIG 13. Vehicle shown with its full complement of personnel plus their TO&E equipment.

FIG 14. The soldier seated directly in front of the radio, blocks the radio controls from the Commander, and his helmet frequently disrupts the controls.

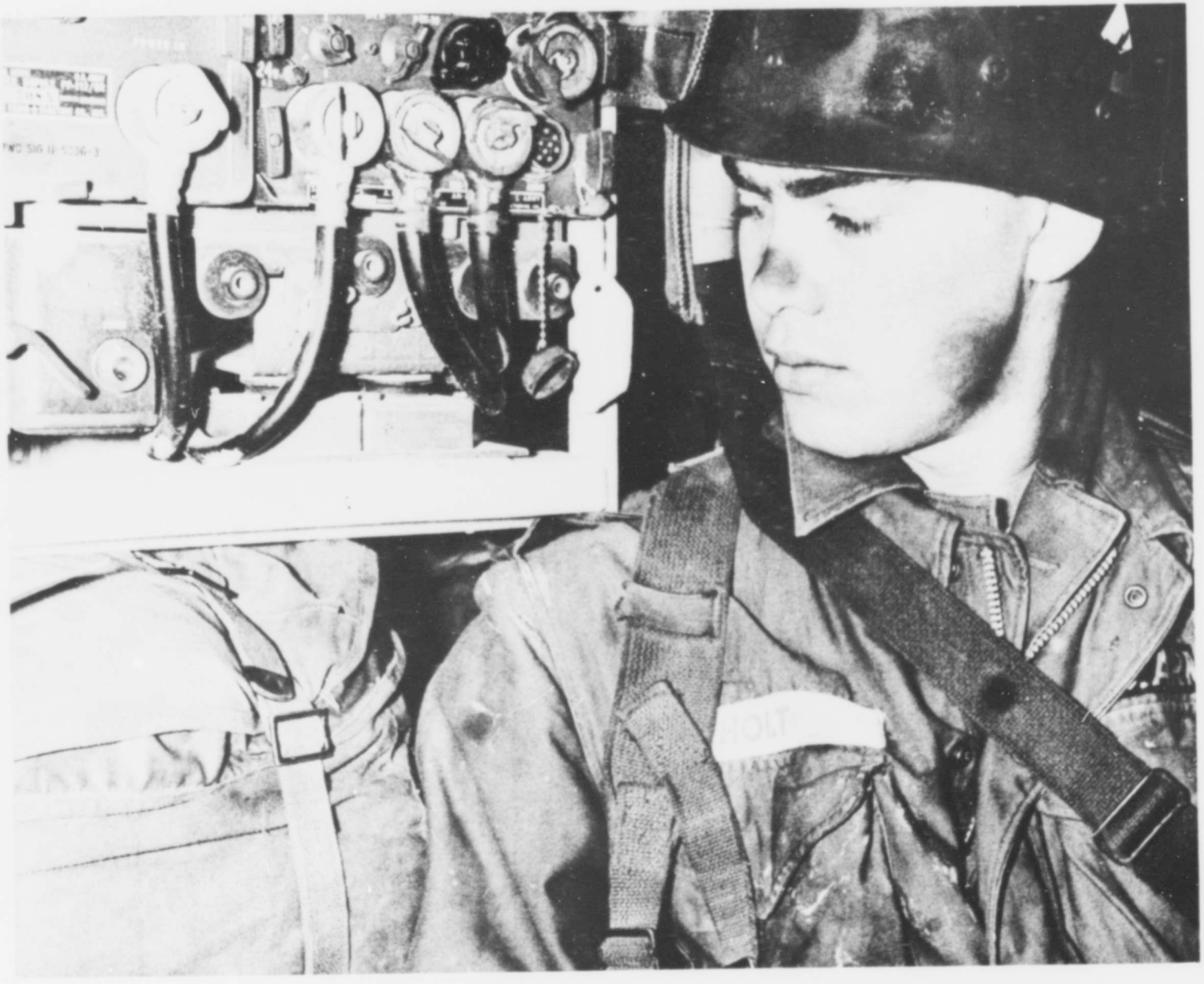


FIG 15. The proximity of the soldier's shoulder to the edge of the radio is hazardous.

RECOMMENDATIONS

The following recommendations, made from a Human Engineering standpoint, should be considered in order to optimize the T113 and T117 vehicles.

a. In order to give the tall man some head clearance in the buttoned position, the commander and driver's hatches should be dome-shaped. Also the accelerator should be designed to allow the short man to place his entire foot on the pedal, not just the tip of his toe.

b. An access door in the engine panel to the right of the driver would permit the checking of oil without removing the panel. The possibility should be explored of attaching an extension sleeve from the present engine oil stick sleeve, and the transmission oil stick sleeve to the access panel, so that only the handles of the two dipsticks would protrude from the driver's side of the panel. This would permit the driver to check both oil levels from within the vehicle.

c. The use of an oil check stick with limited markings is recommended. Two marks should be used -- "Full" and "Add Oil."

d. The feasibility of eliminating blind areas in the periscope assembly should be investigated. Padding the area around the periscope is needed to prevent injury to driver and commander.

e. A "U"-shaped hand grip placed on the wall in front of the commander would provide him with a means of bracing himself in the buttoned position.

f. The radio should be made more accessible to the commander by relocation or some means of remote control. The radio controls should have locking qualities to prevent inadvertent movement by crew members. Rounding the edge of the radio case would prevent the possibility of injury to personnel.

g. The T-shaped screw lock, which permits the commander to turn his cupola, should be located in the "up" position so that it can be easily reached while wearing full field gear. To prevent incorrect control movement, a lever-operated friction lock is suggested.

h. In order to accommodate the commander wearing headgear, more room should be made available between the periscope eyepiece and the bottom of the hatch. This would allow him complete terrain coverage, which is not available at present.

i. The bench seats should fit flush to the wall of the vehicle to prevent shovel handles and other equipment being caught, thereby preventing easy egress for the squad members.

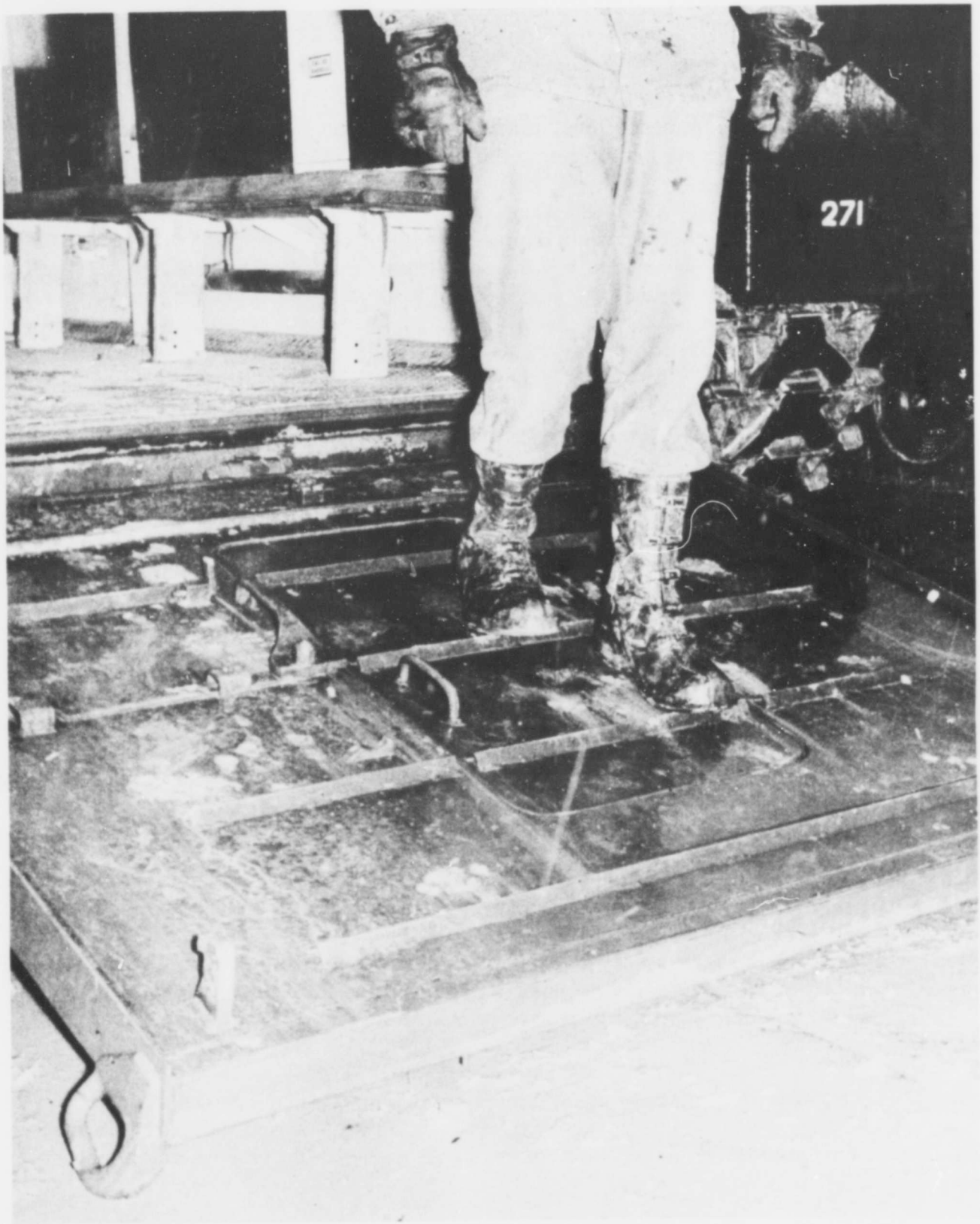


FIG 16. Picture of the horizontal bars on the ramp.

j. In the event of an emergency such as sinking, fire, or blocking of the ramp door, the cargo hatch should be able to be used as an escape hatch. The current design of the commander's hatch in the open position prevents this.

k. Racks, straps, and labels for all OVM, and redesign of current dead space, should be incorporated for better equipment stowage (Fig. 13).

l. The installation of a red blinker light in a conspicuous position within the personnel compartment, which could be operated by the driver, is advised. This would allow the driver to signal the crew when rough or hazardous terrain is to be encountered. The crew in turn would be able to prepare for pitching or braking movements.

m. Rungs similar to those found on the M59 ramp should be installed on the T113 and T117 ramps to prevent slipping (Fig. 16).

n. The feasibility of redesigning the floor plates so that the area below could be utilized for storage space should be studied.

o. In order to prevent hearing damage to personnel who will frequently ride in the vehicles for longer than one year, it is recommended that the sound levels within the T113, T117, and M59 vehicles be reduced to levels below those presented as curve L in Table 1.

p. The base of the commander's platform should be redesigned to increase storage space and permit more leg-room for personnel sitting opposite it.

q. In order to facilitate night operations, a red light or a particular reddish-orange light, which is currently under investigation by this Laboratory, should be located near the center of the personnel compartment. This would allow the squad to prepare their equipment prior to disembarkation, and at the same time allow them to maintain dark adaptation.

r. To eliminate the spring-board action of the ramp when lowered on uneven terrain it should be allowed to extend further below the vehicle.

s. The bilge-pump system should be designed to prevent frequent clogging and to allow easy cleaning and checking. This might be accomplished by providing a greater screening area through the use of a cylindrical screen which can be easily removed, and by providing an access door in the floor plate.

t. A track-tension adjustment mechanism similar to that found on the M59 would facilitate the adjustment operation and eliminate the adjusting cable.

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APPENDIX

ARMOR BOARD TEST SCHEDULE

* * * * * * *

o. (Unclassified) Test Nr 13 - Squad Carrier.

(1) Purpose. To determine the suitability of the test vehicles for use in armor units as rifle and machine gun squad carriers.

(2) Method.

(a) One armored rifle platoon, organized in accordance with TOE 7-27T ROCAD, and fully equipped as in a tactical situation; the 2 test vehicles; and 2 Carriers, Personnel, Armored Full Tracked, M59, will be used. Personnel will wear the field uniform prescribed for the winter season in temperate zones. Each squad will be assigned to one of the vehicles. The platoon headquarters (i.e., platoon leader, platoon sergeant, and messenger) will be assigned as considered most appropriate with respect to the intended use of the locations for key personnel and will be changed during the course of the test operations so that, as a minimum, platoon headquarters personnel, the machine gun squad, and one rifle squad shall have been transported in and engaged in operations from each test vehicle and from one M59. Throughout all tests, the platoon leader will command the platoon.

(b) The following operations will be conducted.

1. Crew drill as outlined in appendix II, FM 17-20. Difficulties, if any, experienced by personnel in mounting and dismounting from the vehicles will be noted.

2. Secondary road movement. Test personnel will be moved in the vehicles to which assigned to an assembly area over secondary hard surface and gravel roads at normal convoy speeds (20 mph). Route selected will be such that the movement will require approximately 2 hours.

3. Cross-country movement. Test personnel will move in the vehicles to which assigned cross country (off roads) for a period of 1 hour. At the end of this period, battle drill as outlined in FM 17-20 will be conducted for a period of 2 hours.

4. Hasty river crossing. Test personnel will move in the vehicles to which assigned in a tactical problem designed to simulate a hasty river crossing operation. Procedure for employment of armored personnel carriers in a hasty river crossing operation as outlined in appendix V, US CONARC Training Text 17-1-1, Armor Operations Small Units, Feb 57, will be used as a guide.

(c) The following will be determined.

1. The most desirable utilization and adequacy of seating provisions in a test vehicle for an armored rifle squad and for an armored machine gun squad.

2. The maximum number of fully equipped armored rifle platoon personnel that can be accommodated in a test vehicle as in an emergency movement.

(d) Throughout all testing, observations will be made and test personnel questioned as to influence, both favorable and unfavorable, of vehicle configuration, performance, and any other feature or characteristic, on results. (Personnel from Human Engineering Laboratory, Aberdeen Proving Ground, will be present during this test to observe test operations, and to question personnel and to note their condition and performance in various test phases.) In the event the results of any of the above tests are inconclusive, they will be repeated or continued, as appropriate, until the effect of the test items on the ability of the platoon personnel to perform essential tasks under all conditions imposed can be evaluated and suitability of the test items within the scope of the test can be determined.

* * * * * * *